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JC514 U.S. PTO  
10/31/97

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Docket No. \_\_\_\_\_  
Anticipated Classification of this application:  
Class \_\_\_\_\_ Subclass \_\_\_\_\_  
Prior application: \_\_\_\_\_  
Examiner: Jones  
1205  
Art Unit: \_\_\_\_\_

Commissioner of Patents and Trademarks  
Washington, D.C. 20231

FILING UNDER 37 CFR 1.60

- WARNING:** *A c-i-p (continuation-in-part) cannot be filed under 37 CFR 1.60.*  
**WARNING:** *Filing under 37 CFR 1.60 is permitted only if filed by the same or less than all the inventors named in the prior application.*  
**WARNING:** *The filing of an application as the United States stage of an International Application requires an oath or declaration. 37 CFR 1.61(a)(4).*  
**WARNING:** *The claims of this new application may be finally rejected in the first Office action where all claims of the new application are drawn to the same invention claimed in the earlier application and would have been properly finally rejected on the grounds or art of record in the next Office action if they had been entered in the earlier application. MPEP § 706.07(b).*

This is a request for filing a

- ☒ Continuation  
☐ Divisional

application under 37 CFR 1.60, of pending prior application

serial no. 08/167,900 filed on July 29, 1994  
(date)

of John M. CARNEY and Robert A. FLOYD

(inventor(s))

for SPIN-TRAPPING PHARMACEUTICAL COMPOSITIONS AND METHODS OF USE THEREOF  
(title of invention)

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this 37 CFR 1.60 request and the documents referred to as attached therein are being deposited with the United States Postal Service on this date \_\_\_\_\_ in an envelope as "Express Mail Post Office to Addressee" service under 37 CFR 1.10, Mailing Label Number \_\_\_\_\_ addressed to the: Commissioner of Patents and Trademarks, Washington, D.C. 20231

(Type or print name of person mailing paper)

(Signature of person mailing paper)

**NOTE:** *Each paper or fee filed by "Express Mail" must have the number of the "Express Mail" mailing label placed thereon prior to mailing. (37 CFR 1.10(b)).*

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NOTE: 37 CFR 1.60 permits the omission of a declaration only if the prior application was complete as set forth in 37 CFR 1.51(a), namely, the prior application comprised at least (1) a specification, including a claim or claims; (2) a declaration; (3) drawings when necessary; and (4) the prescribed filing fee. Accordingly, as presently worded, 37 CFR 1.60 does not permit this procedure to be used where the prior application is pending but only the processing and retention fee required by 37 CFR 1.21(l) is paid or where the declaration was not filed.

## 1. Copy of Prior Application as Filed Which is Attached

NOTE: Under 37 CFR 1.60 practice signing and execution of the application by the applicant may be omitted provided the copy is supplied by and accompanied by a statement by the applicant or his or her attorney or agent that the application papers comprise a true copy of the prior application as filed and that no amendments referred to in the declaration filed to complete the prior application introduced new matter therein.

NOTE: This statement need not be verified if made by an attorney registered to practice before the PTO. (37 CFR 1.60(b)).

- ☒ I hereby verify that the attached papers are a true copy of what is shown in my records to be the above identified prior application, including the oath or declaration originally filed (37 CFR 1.60)

The copy of the papers of prior application as filed which are attached are as follows:

- ☒ 36 page(s) of specification  
☒ 14 page(s) of claims  
☒ 1 page(s) of abstract  
☐ \_\_\_\_\_ sheet(s) of drawing

(Also complete 5 below if drawings are to be transferred)

- ☒ 6 pages of declaration and power of attorney

If the copy of the declaration being filed does not show applicant's signature indicate thereon that it was signed and complete the following:

- ☒ in accordance with the indication required by 37 CFR 60(b) my records reflect that the original signed declaration showing applicant's signature was filed on March 25, 1994  
☐ the amendment referred to in the declaration filed to complete the prior application and I hereby state, in accordance with the requirements of 37 CFR 1.60(b), that this amendment did not introduce new matter therein.

## 2. Amendments

**WARNING:** "The claim of a new application may be finally rejected in the first Office action in those situations where (1) the new application is a continuing application of, or a substitute for, an earlier application, and (2) all the claims of the new application (a) are drawn to the same invention claimed in the earlier application, and (b) would have been properly finally rejected on the grounds or art of record in the next Office action if they had been entered in the earlier application." MPEP § 706.07(b).

- ☐ Cancel in this application original claims \_\_\_\_\_ of the prior application before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)  
☐ A preliminary amendment is enclosed. (Claims added by this amendment have been properly numbered consecutively beginning with the number next following the highest numbered original claim in the prior application.)

NOTE: Only amendments reducing the number of claims or adding a reference to the prior application (Rule 1.78(a)) will be entered before calculating the filing fee and granting the filing date. 37 CFR 1.60(b).

NOTE: "When filing under Rule 1.60 retain at least one original claim from the patent application to assure a complete application." Notice of March 3, 1986 (1064 O.G. 37-38).

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### 3. Fee Calculation

CLAIMS AS FILED					
Number filed	Number Extra			Rate	Basic Fee \$790.00
Total Claims	16	-20=	0	×	\$ 22.00
Independent Claims	2	-3=	0	×	\$ 82.00
Multiple dependent claim(s), if any				×	\$ 270.00

☐ Fee for extra claims is not being paid at this time.

**NOTE:** If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency. 37 CFR 1.16(d).

Filing Fee Calculation

\$ 790.00

### 4. Small Entity Status

☐ A verified statement that this filing is by a small entity:

☐ is attached

☐ has been filed in the parent application and such status is still proper and desired (37 CFR 1.28(a))

Filing Fee Calculation (50% of above) \$

**NOTE:** Any excess of the full fee paid will be refunded if a verified statement is filed within 2 months of the date of timely payment of a full fee then the excess fee paid will be refunded on request. 37 CFR 1.28(a).

**NOTE:** 37 CFR 1.28(a), last sentence states: "Applications filed under §1.60 or §1.62 of this part must include a reference to a verified statement in a parent application if status as a small entity is still proper and desired."

### 5. Drawings

**WARNING:** Do not check the following box if prior case is not to be abandoned.

☐ Transfer the drawings from the prior application to this application and, subject to Item 16 below, abandon said prior application as of the filing date accorded this application. A duplicate copy of this request is enclosed for filing in the prior application file. (May only be used if signed by (1) applicant, (2) assignee of record or (3) attorney or agent of record authorized by 37 CFR 1.138 and before payment of issue fee.)

**NOTE:** "A registered attorney or agent acting under the provisions of § 1.34(a), or of record, may also expressly abandon a prior application as of the filing date granted to a continuing application when filing such a continuing application." 37 CFR 1.138

☐ Transfer the following sheet(s) of drawing from the prior application to this application

**NOTE:** Transferred sheets must be cancelled in prior application. 37 CFR 1.88.

☐ New drawings are enclosed

☐ formal

☐ informal

**NOTE:** The Notice of October 7, 1985 (1059 O.G. 2" 39) states the following: "Submission of Drawings—For your convenience and for more effective handling of any drawing corrections which may be necessary, please DO NOT SUBMIT ORIGINAL DRAWINGS WITH PATENT APPLICATIONS. DO SUBMIT THREE HIGH QUALITY COPIES. If the copies submitted pass the formality review and patent examination, no substitute

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drawings will be necessary. If corrections are necessary, they should be made to the original drawings. Either a good copy of the corrected drawings or the corrected original can then be submitted after the Notice of Allowability is mailed." The Notice of November 25, 1985 (1061 O.G. 12) further clarifies the submission of drawing practice by pointing out that the copies that are submitted to the office must be on strong, white, smooth and non-shiny paper and also points out that drawings for patent applications do not need to be submitted on bristol board.

**6. Priority—35 U.S.C. 119**

- ☐ Priority of application serial no. \_\_\_\_\_ filed on \_\_\_\_\_ in \_\_\_\_\_ (country) is claimed under 35 U.S.C. 119.
- ☐ The certified copy has been filed in prior U.S. application serial no. \_\_\_\_\_ on \_\_\_\_\_
- ☐ the certified copy will follow

**7. Relate Back—35 U.S.C. 120**

- ☐ Amend the specification by inserting before the first line the sentence:  
This is a  
☐ continuation  
☐ divisional  
of co-pending application serial no. \_\_\_\_\_ filed on \_\_\_\_\_

**8. Inventorship Statement**

**NOTE:** If the continuation or divisional application is filed by less than all the inventors named in the prior application a statement must accompany the application when filed requesting deletion of the names of the person or persons who are not inventors of the invention being claimed in the continuation or divisional application. 37 CFR 1.60(b) [emphasis added]

(complete appropriate items (a) and (b))

- (a) With respect to the prior copending U.S. application from which this application claims benefit under 35 USC 120 the inventor(s) in this application is (are):

(complete applicable item below)

- ☒ the same
- ☐ less than those named in the prior application and it is requested that the following inventor(s) identified above for the prior application be deleted:

\_\_\_\_\_  
(Type name(s) of inventor(s) to be deleted)

- (b) The inventorship for all the claims in this application are

- ☒ the same
- ☐ not the same, and an explanation, including the ownership of the various claims at the time the last claimed invention was made, is submitted.

**9. Assignment**

- ☒ The prior application is assigned of record to  
OKLAHOMA MEDICAL RESEARCH FOUNDATION AND UNIVERSITY OF  
KENTUCKY RESEARCH FOUNDATION
- ☐ an assignment of the invention to \_\_\_\_\_  
\_\_\_\_\_ is attached

10. Fee Payment Being Made At This Time

- ☐ Not Enclosed
- ☐ No filing fee is submitted. (This and the surcharge required by 37 CFR 1.16(e) can be paid subsequently).
- ☒ Enclosed
- ☒ basic filing fee \$ 790.00
- ☐ recording assignment (\$40.00 37 CFR 1.21(h)(1)) \$
- ☐ processing and retention fee (\$120.00 37 CFR 1.53(d) and 1.21(i)) \$

**NOTE:** 37 CFR 1.21(i) establishes a fee for processing and retaining any application which is abandoned for failing to complete the application pursuant to 37 CFR 1.53(d) and this, as well as the changes to 37 CFR 1.53 and 1.78 indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee or the processing and retention fee of \$ 1.21(i) within 1 year from notification under § 53(d) must be paid.

Total fees enclosed

\$ 790.00

11. Method of Payment of Fees

- ☒ enclosed is a check in the amount of \$ 790.00
- ☐ charge Account No. in the amount of \$
- A duplicate of this request is attached.

**NOTE:** Fees should be itemized in such a manner that is clear for which purpose the fees are paid. 37 CFR 1.22(b).

12. Authorization To Charge Additional Fees

**WARNING:** If no fees are being paid on filing do not complete this item.

**WARNING:** Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges if extra claim charges are authorized.

- ☒ The Commissioner is hereby authorized to charge the following additional fees which may be required by this paper and during the entire pendency of the application to Account No. 10-1213

☒ 37 CFR 1.16 (filing fees)

☒ 37 CFR 1.16 (presentation of extra claims)

**NOTE:** Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 CFR 1.16(d)) it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

☒ 37 CFR 1.17 (application processing fees)

**WARNING:** While 37 CFR 1.17(a), (b), (c) and (d) deal with extensions of time under § 1.136(a) this authorization should be made only with the knowledge that: "Submission of the appropriate extension fee under 37 CFR 1.136(a) is to no avail unless a request or petition for extension is filed." (Emphasis added). Notice of November 5, 1985 (1060 O.G. 27).

☐ 37 CFR 1.18 (issue fee at or before mailing Notice of Allowance, pursuant to 37 CFR 1.311(b)).

**NOTE:** Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 CFR 1.311(b)).

**NOTE:** 37 CFR 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying or at the time of paying . . . issue fee." From the wording of 37 CFR 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

(37 CFR 1.60 [4-3]—page 5 of 7)

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- ☒ The power of attorney in the prior application is to

George M. Cooper, Eric S. Spector, Felix J. D'Ambrosio,  
Douglas R. Hanscom, James W. Hellwege, William A. Blake,  
Colin D. Barnitz

- a. ☐ The power appears in the original papers in the prior application  
b. ☒ Since the power does not appear in the original papers, a copy of the power in the prior application is enclosed.  
c. ☐ A new power has been executed and is attached.  
d. ☒ Address all future communications to

James W. Hellwege  
JONES, TULLAR & COOPER, P.C.  
P.O. Box 2266 Eads Station  
Arlington, VA 22202

14. Maintenance of Copendency of Prior Application

*(This item must be completed and the papers filed in the prior application if the period set in the prior application has run)*

- ☐ A petition, fee and response has been filed to extend the term in the pending prior application until \_\_\_\_\_

NOTE: The PTO finds it useful if a copy of the petition filed in the prior application extending the term for response is filed with the papers constituting the filing of the Continuation Application. Notice of November 5, 1985 (1060 O.G. 27)

- ☐ A copy of the petition for extension of time in the prior application is attached.

15. Conditional Petition for Extension of Time in Prior Application

*(complete this item and file conditional petition in the prior application if previous item not applicable)*

- ☐ a conditional petition for extension of time is being filed in the pending parent application.

NOTE: The PTO finds it useful if a copy of the petition filed in the prior application extending the term for response is filed with the paper constituting the filing of the continuation application. Notice of November 5, 1985 (1060 O.G. 27).

- ☐ A copy of the conditional petition for extension of time in the prior application is attached.

16. Abandonment of Prior Application (if applicable)

WARNING: (Do not complete this item if the application being filed is a divisional of the prior application which is not being abandoned)

NOTE: "A registered attorney or agent acting under the provisions of § 1.34(a), or of record, may also expressly abandon a prior application as of the filing date granted to a continuing application when filing such a continuing application." 37 CFR 1.138.

- ☐ Please abandon the prior application at a time while the prior application is pending or when the petition for extension of time or to revive in that application

is granted and when this application is granted a filing date so as to make this application copending with said prior application.

I hereby declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

James W. Hellwege

Type or print name of person signing

October 31, 1997

Date JONES, TULLAR & COOPER, P.C.  
P.O. Box 2266 Eads Station

Signature

P.O. Address of Signatory

Arlington, VA 22202

Tel. No.: (703) 415-1500

Reg. No. 28,808

(if applicable)

- ☐ Inventor  
☐ Assignee of complete interest  
☐ Person authorized to sign on behalf of assignee  
☒ Attorney or agent of record  
☐ Filed under Rule 34(a)

(Complete the following if applicable)

Type name of assignee

Address of assignee

Title of person authorized to sign on behalf of assignee

Assignment recorded in PTO on

Reel Frame

SPIN TRAPPING PHARMACEUTICAL COMPOSITIONS  
AND METHODS FOR USE THEREOF

Background of the Invention

The present invention is a method and compositions containing spin trapping agents for the treatment of dysfunctions and disease conditions arising from oxidative damage.

Oxygenated tissue suffers damage, in many cases permanent damage, if it becomes ischemic and is then reperfused. Brain appears to be highly susceptible to ischemia/reperfusion injury. Certain areas of the brain, for example, the hippocampus and spinal cord, are more susceptible than other regions of the brain. As a result, ischemia/reperfusion injury to brain may have a multiplicative effect simply because of the necessity for complete integrity of all regions in order to have proper functioning.

Free radicals have been postulated to be mediators of reperfusion damage. The most likely sites for production of such radicals as the superoxide ( $O_2^-$ ) and hydroxyl ( $OH^\cdot$ ) species, and the precursor oxygen species,  $H_2O_2$  are the mitochondrial respiratory chain specific enzymes and the sequences catalyzed by cyclooxygenase and lipoxygenase. However, radicals are also formed during autoxidation of many compounds (e.g., catecholamines). Ischemia appears to favor a spurt of free-radical formation, resulting in oxidation of polyenoic free fatty acids, release and reuptake of catecholamines, and oxidation of hypoxanthine by xanthine oxidase. Despite these events occurring during recirculation, when the  $O_2$  supply is restored, they represent metabolic cascades triggered by agonist-

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Although free radical formation has been postulated to be a likely cause of ischemic damage, it was difficult to directly demonstrate that such formation occurs and/or that it was sufficiently pronounced to overwhelm the antioxidative defense of the tissue, as reviewed by Curran, et al., Mol. Cell. Biol. 5, 167-172 (1985). Phenyl butyl nitron (PBN) has been used in a number of these *in vitro* research studies using spin trapping to look for free radicals, but until demonstrated by the data in U.S. Serial No. 07/422,651, there has been no data to support the proposition that it could be useful *in vivo*, particularly with respect to treatment of tissue damage in the central nervous system. *In vivo*, the drug must be able to both cross the blood brain barrier and act in a manner which reduces tissue damage during or following ischemia.

In U.S. Serial No. 07/589,177, the use of PBN and related compounds, as well as 5,5-dimethyl pyrroline N-oxide (DMPO) and  $\alpha$ -(4-pyridinyl-1-oxide)-N-tert-butyl nitron (POBN), for treatment of aging was described. Age related changes in central nervous system function have generally been associated with the loss of cells, a widening of lateral ventricles and deficits in short term memory. The precise mechanisms of functional changes as a result of aging, or other diseases associated with aging, have not generally been agreed upon, including several mechanisms for the generation of oxidized material in the brain. A marked reduction in certain neurotransmitter receptor systems has been associated with increased oxidation of proteins. For example, decreases in muscarinic receptors and other cholinergic systems have been characterized as they relate to alterations in functions

in Alheimers disease. It is now known that the processes of aging and Alzheimer's disease are associated with oxidation of brain proteins. It has also been hypothesized that aging is associated with multiple minor periods of ischemia (multi-infarct conditions or transient ischemia attacks) which, over a period of time, may give rise to the production of oxidized protein.

The demonstration in a variety of systems, both neural and nonneural, that there is an age related enhancement of the level of oxidized protein in tissue gives rise to the possibility that age related dysfunctions in the central nervous system may be associated with the build-up of oxidized proteins and oxidized macromolecules within neurons throughout the central nervous system. The hypothesis is that cells which have a buildup of oxidized protein are less functional and less able to maintain the specified role of those cells in that particular area of the central nervous system. The data presented in U.S. Serial No. 07/589,177 was the first report of substantial investigations in which alterations in the oxidized protein burden of the central nervous system was manipulated and correlated with a functional outcome on the part of the animal. There are a number of other disorders and diseases which have now been postulated to be associated with oxidation of proteins, including many central nervous system (CNS) diseases besides stroke and aging, including Parkinsonism, trauma, vascular headaches, cerebral palsy, diabetic neuropathy, and neuroanesthesia adjunct, as well as peripheral nervous system diseases such as diabetic peripheral neuropathy and traumatic nerve damage, as well as peripheral organ diseases. Examples of peripheral organ diseases include atherosclerosis, pulmonary fibrosis, pancreatitis, angioplasty, multiple organ failure, burns, decubitus ulcers, and ischemic bowel disease.

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### Summary of the Invention

Spin trapping compounds in general have now been discovered to be effective in treating a variety of disorders, including disorders such as those arising from ischemia, infection, inflammation, exposure to radiation or cytotoxic compounds, not just of the central and peripheral nervous systems but of peripheral organ disease having a wide variety of etiologies.

Spin trapping compounds as referred to herein are molecules that (1) have an unpaired electron; (2) form a stable compound or complex with a free radical; and (3) are nontoxic, i.e., have a therapeutic index (margin of safety;  $EC_{50}/LC_{50}$ ) of 3 or more.

The spin traps provide a unique signal that can be measured by electron spin spectroscopy (ESR) when it binds to a free radical. For example, the oxidation of brain tissue involves a free radical intermediate. Brain tissue that has been treated with PBN has been monitored by ESR. As a free radical on a lipid or protein is generated, PBN traps the radical and forms a covalently bound product with the material, which has a characteristically unique ESR signal. The PBN-(lipid or protein) has then been isolated and identified.

A wide range of spin trapping compounds are disclosed in detail herein. Other spin traps that meet the above three requirements are known to those of skill in the art of organic and medicinal chemistry. An essential criteria for the selection of the spin trap is that it actively trap free radicals without cytotoxicity, and that in the applications where access to the CNS is required for efficacy, that the compounds pass through the blood brain barrier.

Many different disorders can be treated using these compounds, including diseases or disorders of the central and peripheral nervous systems, and disorders

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arising from ischemia, infection, inflammation, oxidation from exposure to radiation or cytotoxic compounds, as well as due to naturally occurring processes such as aging.

### Detailed Description of the Invention

The term alkyl, as used herein, unless otherwise specified, refers to a saturated straight, branched, or cyclic hydrocarbon of  $C_1$  to  $C_{10}$ , and specifically includes methyl, ethyl, propyl, isopropyl, cyclopropyl, butyl, isobutyl, t-butyl, pentyl, cyclopentyl, isopentyl, neopentyl, hexyl, isohexyl, cyclohexyl, 3-methylpentyl, 2,2-dimethylbutyl, and 2,3-dimethylbutyl, and cyclohexyl.

The term alkenyl, as referred to herein, and unless otherwise specified, refers to a straight, branched, or cyclic (in the case of  $C_{5-6}$ ) hydrocarbon of  $C_2$  to  $C_{10}$  with at least one double bond.

The term aryl, as used herein, and unless otherwise specified, refers to phenyl or substituted phenyl, wherein the substituent is halo or lower alkyl.

The term halo, as used herein, includes fluoro, chloro, bromo, and iodo.

The term aralkyl refers to an aryl group with an alkyl substituent.

The term alkaryl refers to an alkyl group that has an aryl substituent.

The term halo (alkyl or alkenyl) refers to an alkyl or alkenyl group in which at least one of the hydrogens in the group has been replaced with a halogen atom. The term haloalkyl specifically includes trifluoromethyl.

The term aralkyl refers to an aryl group with an alkyl substituent.

The term pharmaceutically active derivative refers to any compound that upon administration to the

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recipient, is capable of providing directly or indirectly, the compounds disclosed herein.

The term alkaryl refers to an alkyl group that has an aryl substituent.

The term nontoxic refers to a compound that has a therapeutic index of at least three.

The invention disclosed herein includes pharmaceutical compositions that contain spin trapping compounds or pharmaceutically acceptable derivatives or salts thereof for use in medical therapy, for example for the treatment or prophylaxis of disorders such as those arising from ischemia, infection, inflammation, exposure to radiation or cytotoxic compounds, not just of the central and peripheral nervous systems but of peripheral organ disease having a wide variety of etiologies.

The invention also includes the use of spin trapping agents and pharmaceutically acceptable derivatives or salts thereof in the manufacture of a medicament for treatment or prophylaxis of disorders such as those arising from ischemia, infection, inflammation, exposure to radiation or cytotoxic compounds, not just of the central and peripheral nervous systems but of peripheral organ disease having a wide variety of etiologies.

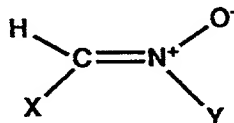
It has now been discovered that spin-trapping agents are generally useful in preventing or treating symptoms associated with a very wide range of disorders of the central and peripheral nervous system, as well as peripheral organ disfunction and disease, including not just aging, trauma, ischemia, but disorders as disparate as undesirable ratios of lipoproteins, ulcerative colitis, and damage arising from exposure to radiation and cytotoxic compounds (chemotherapeutic compounds, in most instances).

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# Useful Spin-trapping compounds.

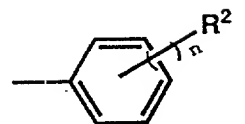
## PBN and derivatives thereof.

The preferred spin-trapping compounds are phenyl N-~~tert~~-butylnitrone, also referred to as  $\alpha$ -phenyl t-butyl nitron (PBN), and derivatives thereof of the formula:



wherein:

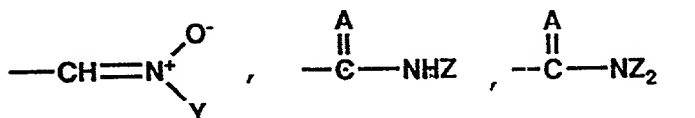
X is phenyl, imidazolyl, phenothiazinyl or

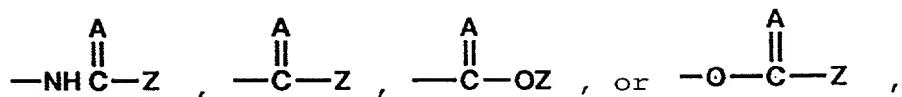


$n=1-5$ , preferably 1-3;

$\text{R}^2$  = independently (can vary within the molecule) halogen, alkyl, oxyalkyl, alkenyl, oxyalkenyl, OH,

$\text{NH}_2$ ,  $\text{NHZ}$ ,  $\text{NZ}_2$ , NO,



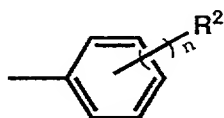


$\text{--SO}_3\text{H}$ ,  $\text{--OSO}_3\text{H}$ ,  $\text{SH}$ ,  $\text{--S(alkyl)}$ ,  $\text{--S(alkenyl)}$ , and haloalkyl, specifically including  $\text{--CF}_3$ ;

A = O or S; and

Z is a  $\text{C}_1$  to  $\text{C}_6$  straight, branched, alkyl or cyclic group; and

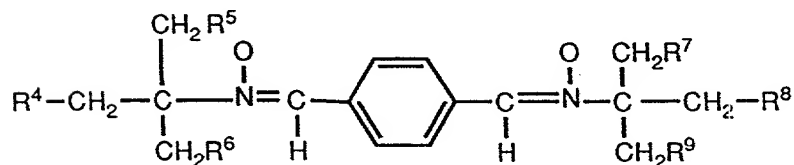
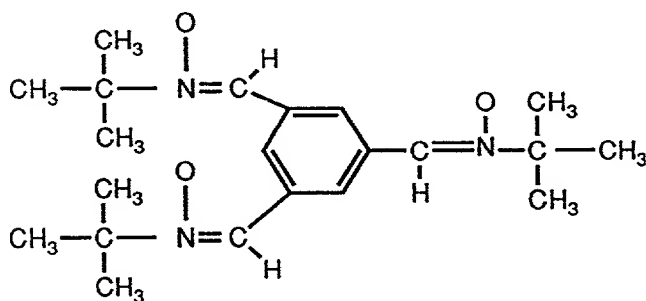
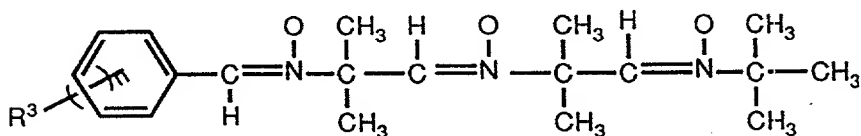
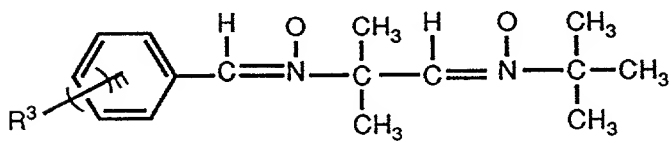
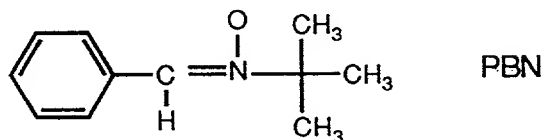
Y is a tert-butyl group that can be hydroxylated or acetylated at one or more positions; phenyl or

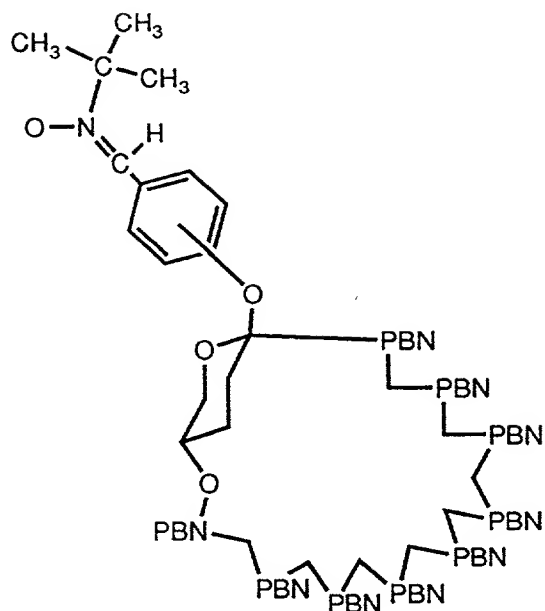


PBN is the most preferred compound at this time, having no measurable effect on normal or uninjured cells, although a number of derivatives are also useful, including hydroxy derivatives, especially 2-, 3- or 4-hydroxyphenyl t-butyl nitron and phenyl (mono-, di- or trihydroxy) tert-butyl nitron; PBN esters, especially esters which release 2-, 3-, or 4-hydroxyphenyl t-butyl nitron such as the acetoxy derivative; 2-, 3-, or 4-carboxyphenyl t-butyl nitron; phenyl hydroxybutyl nitron; alkoxyl derivatives, especially alkoxyl derivatives which release 2-, 3-, or 4-hydroxyphenyl t-butyl nitron, for example, the 2-, 3-, or 4- methoxyphenyl derivatives of PBN; and acetamide derivatives, especially acetamide derivatives which release 2-, 3-, or 4- aminophenyl t-butyl nitron; diphenyl nitron (PPN) and the analogous diphenyl nitron derivatives; N-tert-butyl- $\alpha$ -(4-nitro-phenyl) nitron; and N-tert-butyl- $\alpha$ -(2-sulfophenyl) nitron. As used herein, "PBN" refers to both phenyl N-tert-butyl

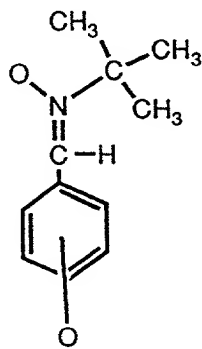



nitron and derivatives thereof, unless otherwise stated. Formulas for PBN and specific derivatives thereof are:

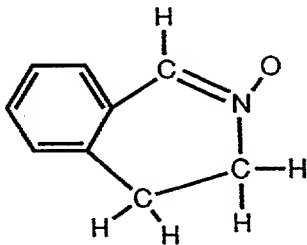




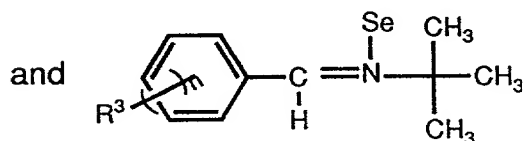
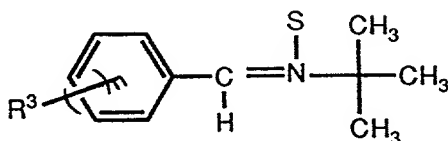
Example of PBN ( $\alpha$ ,  $\beta$ , or  $\gamma$ ) CYCLODEXTRAN POLYMER



wherein PBN =  connected through one or more hydroxyl moieties of the cyclodextran



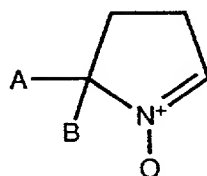
PBN CYCLIZED



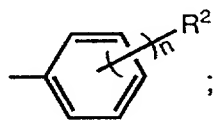
Other spin-trapping agents can also be used, such as 5,5-dimethyl pyrroline N-oxide (DMPO),  $\alpha$ -(4-pyridyl 1-oxide)-N-tert-butyl nitron (POBN), 3,3,5,5-tetramethyl-1-pyrroline N-oxide, and 2,4,4,6-tri-tert-butyl nitrosobenzene (BNB), and spin-trapping derivatives thereof. Many compounds are commercially available or can be synthesized using methods known to those skilled in the art.  $\alpha$ -Phenyl-N-phenyl nitron compounds for use as topical antiinflammatories are described by U.S. Patent No. 4,224,340 to Campbell, et al., the teachings of which are incorporated herein.

**DMPO and derivatives thereof.**

The general formula for DMPO, and specific derivatives are:

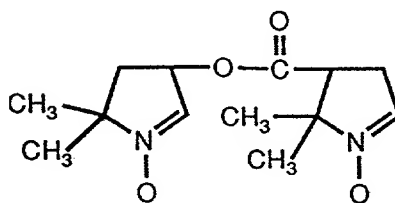


wherein A and B are independently  $-R^2$ ,  $-\text{CH}_2\text{OH}$ ,  $-\text{CH}_2\text{OW}$ , or

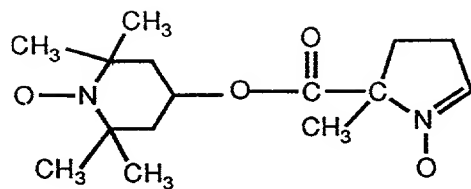


n is an integer from 1 to 5; and

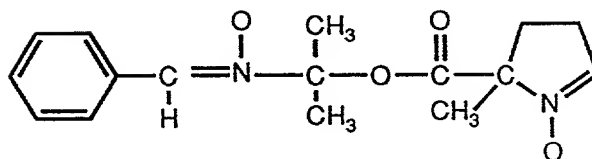
W is  $-\overset{\text{O}}{\parallel}{\text{C}}-\text{Z}$ , specifically including  $-\overset{\text{O}}{\parallel}{\text{C}}\text{CH}_3$ , or  $-\text{Z}$



DMPO dimer



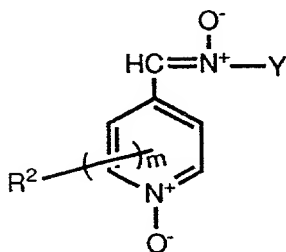
DMPO covalently bound to TEMPO



PBN covalently bound to DMPO

**POBN and derivatives thereof.**

The general formula for POBN is:



wherein  $m = 0$  to 4

**TEMPO and derivatives thereof.**

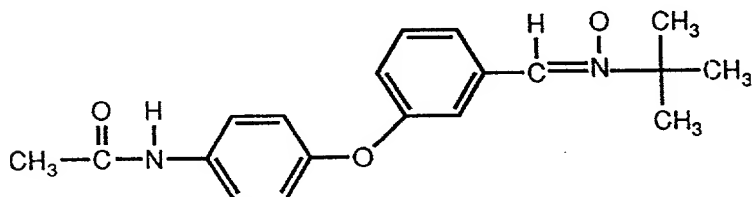
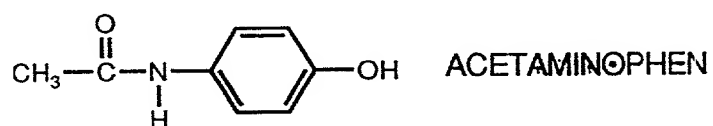
2,2,6,6-Tetramethyl piperidinoxy (TEMPO) is a nitroxide organic free radical trap. The synthesis and chemistry of nitroxide free radicals is referenced by Galfney, B.J., pp. 184-238 in Spin Labeling in Pharmacology, Berliner, L.H., (Academic Press, NY, NY 1976), the teachings of which are incorporated herein. TEMPO and several derivatives thereof can be purchased from Aldrich Chemical Co., as can many other spin traps

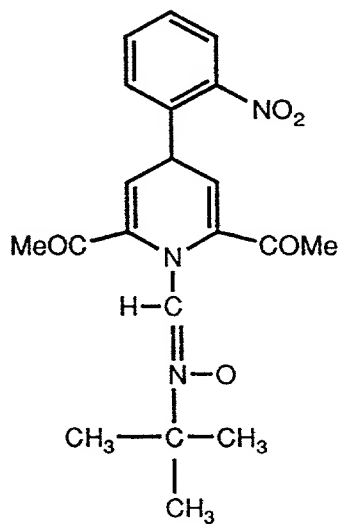
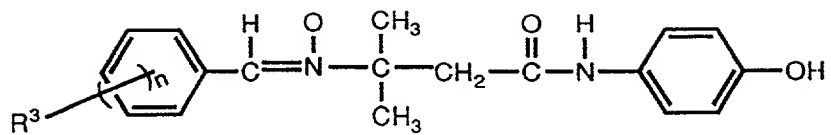
such as PBN, DMPO, and POBN and some of their derivatives.

As discussed above, the important criteria for these compounds is that they must trap free radicals, especially hydroxy and superoxide radicals, while remaining non-toxic to normal cells. In those applications where the compound must reach the brain and other parts of the CNS, the compound must also be low molecular weight to pass through the blood brain barrier. In some applications, the higher molecular weight dimers and polymers of the spin trap may have advantages.

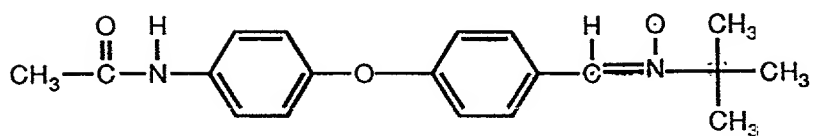
### Conjugates and polymers of spin trapping compounds.

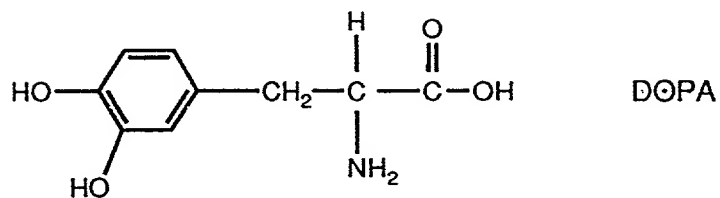
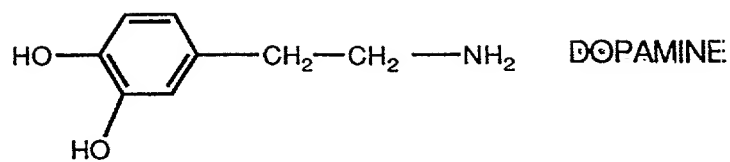
In another embodiment, spin trapping compounds are covalently attached to known pharmaceutical agents, by methods known to those skilled in the art. Examples of useful compounds include spin traps covalently bound to antiinflammatories, neuroactive compounds, antioxidants, or calcium channel blockers. Examples as illustrated include conjugates of acetaminophen, dopamine (or DOPA), vitamin E, and nifedipene.



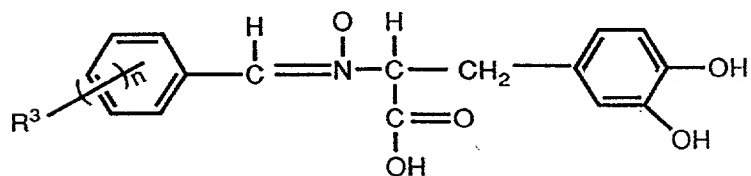
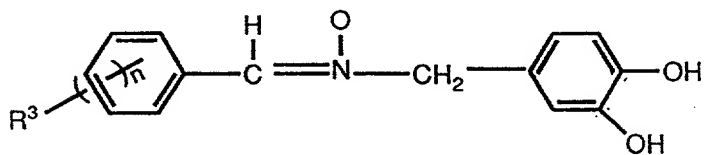
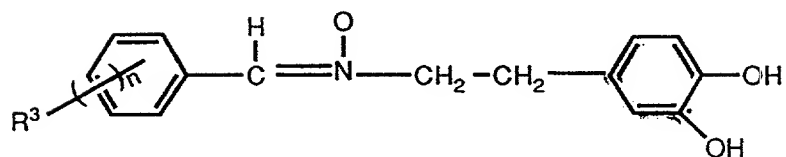
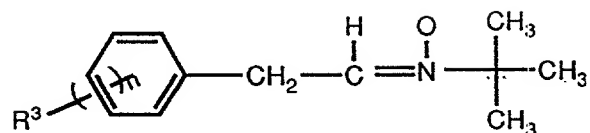


NIFEDIPHENYL PBN





### Derivatives of DOPA







Other drugs that can be covalently bound to the spin traps include calcium channel blockers such as nimodipine, nicardipine, nifedipine, nitrendipine, diltiazem and flunarazine; cardiac glycosides such as digitalis and analogues thereof; adrenergic antagonists such as propranolol; metal chelators such as desferal; modified steroids such as lazaroids; antiinflammatories such as prednisone; nonsteroidal antiinflammatories such as acetaminophen, ibuprofen, and indomethacin; antioxidants such as vitamin E; and neuroactive compounds such as L-DOPA. The optimal position to bind the spin trap to the pharmaceutical agent is easily determined using known information on structure activity relationships and bulk tolerance of the pharmaceutical agent. In some cases spacers will be required between the spin-trap and the conjugated compound in order to preserve maximum activity.

Spin traps can also be attached to antibodies or ligands for specific receptors (such as certain hormones, enzymes, or even specific sugars or carbohydrates) which are used to "target" or otherwise concentrate the spin trapping compound. Depending on the structure of the spin trap, as well as the biologically active compound, it may be necessary to insert a spacer between the spin trap and the biologically active compound.

**Indications that the compositions are useful in treating.**

The spin trap or free-radical scavenger compositions are useful in treating a variety of dysfunctions or disorders characterized by oxidized proteins or lipids in the tissues, cells, or associated fluids (such as the blood). Oxidation of cytosolic protein has been demonstrated to occur in a wide variety of pathological conditions.

Accordingly, compounds which have as their fundamental mechanism of action the interference of production of oxidized protein are useful in the treatment of a wide variety of diseases having what appears at first glance to be widely dissimilar etiologies, because the fundamental cause of the condition is oxidation of protein, nucleic acids, or lipids.

Disorders are generally divided into disorders of the central and peripheral nervous system and disorders of the peripheral organs.

Disorders of the CNS include stroke, aging, Parkinsonism, concussion, aneurysm, ventricular hemorrhage and associated vasospasm, migraine and other vascular headaches, spinal cord trauma, diabetic retinopathy, and neuroanesthesia adjunct. Disorders of the peripheral nervous system include diabetic peripheral neuropathy and traumatic nerve damage.

Peripheral organ disease includes atherosclerosis (both diabetic and spontaneous), chronic obstructive pulmonary disease (COPD), pancreatitis, pulmonary fibrosis due to chemotherapeutic agents, angioplasty, trauma, burns, ischemic bowel disease, wounds, ulcers and bed sores, lupus, ulcerative colitis, organ transplantation, renal hypertension, overexertion of skeletal muscle, and epistaxis (pulmonary bleeding).

Other conditions associated with excessive oxidation of proteins or lipids that can be treated include undesirable or altered oxidation of low density lipoprotein, and dysfunction from exposure to radiation, including x-ray, ultraviolet, gamma and beta radiation, and cytotoxic compounds, including those used for chemotherapy for cancer and viral infections.

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## Stroke

Aqina

Aging has been demonstrated to be associated with the production of abnormally high levels of oxidized proteins. The consequence of this increased level of protein oxidation is an abnormally low level of critical enzymes in the affected cells. While not all cells have been evaluated, it appears from the *in vivo* data presented in U.S. Serial No. 07/589,177 and U.S. Serial No. 07/422,651, and reports of *in vitro* studies, that most, if not all, cells in the body will undergo abnormally high levels of protein oxidation. Decreases in antioxidant systems and abnormally low levels of mitochondrial function have been described. The protein oxidation is thought to arise from oxygen free radicals, largely generated via a metal catalyzed reaction within the cell. Studies have now been conducted that daily administration of a free radical spin trapping compound, PBN, for fourteen days completely reverses this process. Not only is the level of protein oxidation decreased, but the abnormally low level of enzyme activity is restored to normal.

### Parkinsonism

Research has indicated that one of the principle sources of dopaminergic damage to the striatum is via free radical mediated oxidation. Dopamine can be oxidized to the neurotoxin 6-OH dopamine within the neuron. This neurotoxin is activated by a second oxidation. Both of these reactions are thought to occur as a result of oxygen free radical production and attack on the dopamine, a naturally occurring neurotransmitter. These oxygen radical mediated oxidations are thought to occur at a relatively slow rate and to be responsible for the progressive loss of motor function in Parkinsonism and related conditions. Based upon the demonstration that chronic administration of PBN can decrease the progressive oxidation that occurs following a stroke, it is believed that PBN and other spin-trapping compounds will be effective in limiting the production of the neurotoxic dopamine oxidation products.

### Concussion

The majority of the research literature indicates that concussion produces the bulk of its long term effects via interruption of brain and spinal cord microcirculation, producing localized ischemia. This interruption in blood flow can be the result of the initial trauma and shearing of capillaries or the consequence of the brain edema and compression of the blood vessels. In any event, spin trapping compounds are of therapeutic value as they have been demonstrated to be in models of stroke.

### Berry Aneurysm and other types of aneurysm

This vascular problem results in bleeding on the brain and presents as a serious and chronic headache or other neurologic symptom. The condition is ultimately treated by surgical repair of the vessel that has developed a weak wall. However, this condition often results in hemorrhage and neural damage due to the

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bleeding. In addition, the presence of blood on the outside of the vessel sensitizes the vessels to spasm and increases the risk of a stroke, as is also true in concussion and other traumatic conditions. In addition to the radicals generated by spasm and stroke, the iron or other metal catalyzed generation of oxygen free radicals, similar to what has been proposed for ischemia and concussion, also represents a second source of free radicals.

#### Ventricular Hemorrhage and Associated Vasospasm

The same biochemical and physiological conditions as described for Berry Aneurysm and their management by spin trapping compounds will apply for these conditions.

#### Migraine and other Vascular Headaches

Migraines are thought to arise in part from large vessel vasodilation and compression of the microcirculation of the cortex. This is another form of ischemia/reperfusion injury. While spin-trapping compounds will not prevent the initial occurrence of these vascular headaches, they limit the extent or frequency by trapping the free radicals that are generated during the ischemia phase.

#### Spinal Cord Trauma

Spinal cord trauma involves the interruption of the normal vascular supply due to shearing forces at the time of the initial trauma and as a result of the subsequent edema of the tissue. In addition, the hemorrhage that often accompanies such trauma will also generate vasospasm and directly generated oxygen free radicals. Spin trapping compounds limit this process and terminate the intracellular cascade of lipid and protein oxidation.

#### Neuroanesthesia Adjunct

Several procedures involve resection of brain tissue which will result in hemorrhage in the immediate area. Other surgical procedures may be associated with increased risk of cerebral blood flow interruption,

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either as a natural consequence of the procedure, e.g., cardiac surgery or heart transplantation, or due to the unexpected interruption of flow, e.g., hemorrhage, clot following angioplasty, cardiac arrest during surgery. In all of these conditions, spin-trapping compounds will limit free radical mediated damage, and will limit the development of antigenic reactions or other changes in the vascular endothelium that will increase the risk of the development of a reclusive injury. Reduction in free radical mediated damage limits antigen/antibody mediated tissue damage.

#### Peripheral Nervous System Diseases

Diabetics are well known for their tendencies to develop peripheral neuropathies and progressively lose sensation in limbs. In addition, diabetics have a higher risk to develop atherosclerosis, which may affect microvascular function. One of the most frequently seen biochemical consequences of diabetes is excessive glycation of proteins. It is believed that following glycation, there is a burst of protein oxidation that is mediated by oxygen free radicals. It is thought that this process of excessive glycation is critical in the development of damage to neurons and axons in the diabetic. Since spin trapping compounds are quite effective in limiting intracellular free radical mediated damage, such compounds can be used in the chronic management of diabetic neuropathies and other long term adverse consequences of diabetes.

#### Traumatic Nerve Damage

Crushing injury to peripheral nerves, as in the hands, arms, and legs, involves interruption of blood flow (ischemia) and edema. Effective and prompt repair is dependent on the re-establishment of an effective oxygen and nutrient supply. Often recovering tissue tends to outgrow its blood supply and is restricted in recovery by the ischemia that occurs as the tissue outgrows the vascular supply. Spin-trapping compounds

can be used to provide greater tolerance of partial hypoxia as vascular supply grows to reach the healing tissue. In addition, the same ischemia/hypoxia protection that occurs in the non-vascular tissue may also enhance the growth of the endothelia as the revascularization process occurs.

### Peripheral Organ Diseases

#### Atherosclerosis (both diabetic and spontaneous)

Diabetic atherosclerosis involves the abnormal and excessive glycation of protein in the vascular wall. As discussed above for diabetic neuropathy, this involves oxygen radical production and consequent further damage to cytosolic proteins. Spin-trapping compounds will prevent this abnormal processing of cellular protein and other cellular constituents. In vitro studies have been conducted that demonstrate that PBN inhibits or reduces oxidation of low density lipoprotein in plasma. Plasma samples were tested for oxidation of lipid measured using thiobarbituric acid reactive substance ( $T_{BAR}$ , nM) and % inhibition of oxidation calculated. Phosphate buffered saline (PBS) was added to controls, 0.1 mM PBN was added to test samples, and the controls and sealed samples incubated at 4°C for seven weeks.

The results are shown in Table 1.

Table 1: Testing of antioxidation activity of PBN

<u>sample</u>	<u>control + PBS</u>	<u>Test (nM/ml)</u>	<u>%inhibition*</u>
NP132 plasma	0.55	0.45	18. 2
NP134 plasma	0.18	0.14	22. 2
NP135 plasma	0.32	0.25	21. 9
NP133 LDL	0.54	0.28	48. 1
NP135 LDL	0.33	0.11	66. 7

\* The actual percent inhibition in the presence of PBN is greater than the measured value due to interference in the assay by the PBN.



### Chronic Obstructive Pulmonary Disease (COPD)

COPD has been demonstrated to involve the attack of interstitial alveolar macrophages on pulmonary tissue. Animal models of this clinical condition have demonstrated that increases or decreases in superoxide dismutase activity in the lung can result in decreases or increases in pulmonary pathology, respectively. An alternative approach is to provide to the pulmonary tissue, either via the pulmonary vascular supply or via the airway, radical spin-trapping compounds which will limit the peroxidation of pulmonary tissue and the consequent loss of alveolar tissue.

### Pancreatitis

Pancreatitis is believed to be the result of ischemic or chemically derived peroxidation of pancreatic parenchyma. Alcoholic pancreatitis is probably due to the direct effects of the ethanol radical and the indirect vascular effects of acetaldehyde mediated direct damage to proteins and indirect damage via catecholamine release and mitochondrial metabolism. There is currently no treatment for acute pancreatitis. If the condition does not abate, it is generally regarded as fatal in the severe form. Spin -trapping agents can be used to mediate the acute reaction, allowing the patient time to recover.

### Angioplasty

In the process of re-expanding or laser removal of atheroma, there are periods of ischemia and reperfusion of the vessel or energy mediated production of free radicals. Recent studies have demonstrated that during this period, superoxide and nitric oxide are produced. These products have been demonstrated to further damage the endothelium and may also remove or damage the natural relaxant systems that locally control the vascular tone. If uncontrolled, such changes are likely to result in an increased risk of re-occlusion of

the same vessel. Spin-trapping compounds can prevent the generation of the oxy-radical cascade and thereby reduce the likelihood of reocclusion following angioplasty. In the diabetic, there is also an increased risk of cutaneous alteration associated with vascular dysfunction and poor perfusion of the dermis.

#### Multi-organ failure following trauma

A characteristic problem following extreme trauma is the development in the patient of a negative nitrogen balance, poor protein synthetic capacity, pulmonary dysfunction, and abnormal cytokine production. Tumor necrosis factor (TNF) is excessively elevated during this process. TNF is associated with the cellular generation of oxygen free radicals in tissue and may be one of the primary causes of this condition. The activation of macrophages and lymphocytes also plays a critical role in the condition. Free radical production by the white cells is part of the process of multiple organ damage. Spin-trapping compounds can prevent the propagation phase of this condition and limit the extent of cachexia and organ damage following severe trauma.

#### Diabetic Retinopathy

Diabetes is a disease of abnormal glycation and partial ischemia. Both conditions promote free radical production. The relatively common condition of diabetic retinopathy is thought to involve a microvascular and protein dysfunction of the retina. Spin-trapping compounds can limit the glycation mediated production of free radicals and the damage caused by microvascular interruptions.

#### Burn Treatment and Healing

Healing from serious burns is limited by the inability of the repairing vascular system to supply the rapidly growing cutaneum. Periods of ischemia in the dermis will occur as the growing skin cannot be adequately supplied. This hypoxia or ischemia results

in the production of oxygen free radicals and either limits the rate of recovery and/or promotes the generation of scar tissue. Systemic and topical spin-trapping compounds can be used to improve the rate of healing and decrease scar formation.

#### Ischemic Bowel Disease

Strangulation of the bowel is a condition that is frequently fatal in both humans and animals such as dogs, horses and cattle. Even after resection and anastomosis of the intestine, the prognosis is not good. The generation of ischemia derived oxygen radicals and damage to the intestine is considered to be a primary cause. There is no effective treatment to date.

Studies have demonstrated that ischemia induced intestinal edema can be prevented or reduced by a number of different spin-trapping compounds.

Endotoxin is a primary factor in the pathophysiology of equine gastrointestinal disorders and gram negative bacterial infections. The pathophysiological is similar to that characterizing colitis, salmonellosis, and neonatal septicemia. It is hypothesized that endotoxin produces its toxic effects by triggering "oxidative bursts" from sensitized macrophages. These bursts of  $O_2$  radicals are intended to kill invading bacteria associated with the presence of endotoxin. However, they have the adverse effect of damaging the tissues in which they are produced and this tissue damage is presumably the molecular basis of the pathological changes associated with endotoxin shock. Spin-trapping compounds have the ability to trap radicals and alleviate many of the toxic effects associated with radical formation. Additionally, recent experiments demonstrate that spin trap molecules protect rats against endotoxin administration.

#### Wound and Ulcer Healing

Tissue healing often involves periods of hypoxia or ischemia as the recovering tissue outgrows

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intracellular and extracellular carbon-centered free radicals.

It is believed organ survival would therefore be enhanced by administering spin-trapping compounds to the recipient, as well as adding the compounds to the organ preservation solution.

#### **Ionizing Radiation Prophylaxis.**

Ionizing radiation as a therapeutic modality and as an environmental toxicant causes its effects by producing hydroxyl free radicals intracellularly and extracellularly. Ultraviolet radiation acts similarly. The cascade that follows is functionally identical to the process of cellular damage caused by ischemia/reperfusion injury to tissue. Spin-trapping compounds can be used to selectively treat those tissues that are not involved by the cancer, thereby increasing the effectiveness of the therapy and decreasing the side effects of radiation therapies. In the case of environmental exposures, spin-trapping compounds should be effective both as a prophylaxis, applied topically or systemically, as well as a post-exposure therapeutic.

#### **Treatment of Renal Hypertension Disorders, resulting from low renal artery flow and high renin**

Renal hypertension develops as a result of reduced blood flow to the kidney. The juxtaglomerular apparatus (JGA) recognizes this hypoperfusion and releases renin, which results in an angiotensin II mediated increase in blood pressure (hypertension). Hypoperfusion (hypoxia) is a condition that is known to result in significant oxygen free radical production, making it probable that oxygen free radicals are likely to be involved in the release of renin by the JGA, and therefore manageable at least in part through administration of spin-trapping compounds.

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### **Exertional Injury to skeletal muscle**

Sore muscles as a result of exercise are thought to be a consequence of free radical mediated peroxidation of skeletal muscle proteins and lipids. Since chronic treatment with spin-trapping compounds decreases cellular oxidations and protects enzymes from oxidative inactivation, daily treatment can be used to improve the process of exercise conditioning (especially in the horse). Moreover, aged skeletal muscle is likely to contain constituents, as do most other cells in the body. Since work has demonstrated that chronic administration of the spin-trapping compound PBN can return cells to the status of a young adult, spin-trapping can be used to improve the functional status and exercise condition of skeletal muscle in aged individuals.

### **Epistaxis (Pulmonary Bleeding in Horses) and Laminitis**

Epistaxis (ES) and laminitis are both thought to involve ischemia/reperfusion injury to the alveolar basement membrane and the lamina propria of the hoof, respectively. Since both of these conditions involve the process of reperfusion generation of free radicals, spin-trapping compounds can be used in the prevention, management of treatment of these conditions.

### **Pharmaceutical Compositions**

The spin trapping compounds are administered topically, locally, or systemically, depending on the application. When administered systemically, the compound is preferably administered orally or intravenously, in an appropriate pharmaceutical carrier such as saline or phosphate buffered saline (PBS) or in tablet form. For topical application, the compound is preferably administered in an ointment or cream base, or by means of a transdermal patch. The compound can also

be administered by controlled delivery devices, such as biodegradable polymers, or by inhalation, insufflation or nasal spray. Suitable carriers are known to those skilled in the pharmaceutical area.

#### **Effective dosages of Spin Trapping Compounds**

A typical dose of the spin trapping agent for all of the above-mentioned conditions is in the range from about 0.1 to 100 mg/kg, preferably 0.5 to 50 mg/kg, of body weight per day. The effective dosage range of the pharmaceutically acceptable derivatives can be calculated based on the weight of the parent spin trapping compound to be delivered. If the derivative exhibits activity in itself, the effective dosage can be estimated as above using the weight of the derivative, or by other means known to those skilled in the art.

The compound is conveniently administered in any suitable unit dosage form, including but not limited to one containing 5 to 2000 mg, preferably 50 to 1500 mg of active ingredient per unit dosage form. A oral dosage of 50-1000 mg is usually convenient.

Ideally the active ingredient should be administered to achieve peak plasma concentrations of the active compound of from about 0.5 to 100 mM, preferably about 1 to 30 mM.

The concentration of active compound in the drug composition will depend on absorption, inactivation, and excretion rates of the drug as well as other factors known to those of skill in the art. It is to be noted that dosage values will also vary with the severity of the condition to be alleviated. It is to be further understood that for any particular subject, specific dosage regimens should be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the compositions, and that the concentration ranges set forth herein are exemplary only

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and are not intended to limit the scope or practice of the claimed composition. The active ingredient may be administered at once, or may be divided into a number of smaller doses to be administered at varying intervals of time.

Exemplary dosages of the parent phenyl t-butyl nitron administered intravenously range from 0.1 to 10 mg/kg of body weight in animals. The effective dosage of PBN in humans for treating age and ischemic related disorders is expected to be between approximately 1 and 10 mg/ 70 kg body weight. Toxicity tests have demonstrated that PBN is completely innocuous, with such low toxicity that it was not possible to determine an LD<sub>50</sub>. It is possible to extrapolate from comparative tests using other spin trapping compounds what the effective dosage for these compounds will be.

Since the trapping of endogenous free radicals is specific for only those cells that have been exposed to the conditions that result in the production of free radicals, the traps have little or no effect on normal cells. The beneficial effects occur only in injured cells, and do not require the presence of specific receptors, specific enzymes, and/or specific cell types.

#### **Methods of administration of PBN**

The spin trapping compound is preferably administered systemically, most preferably intravenously or orally, since these are the most rapid and efficient means for delivering the active compound to the site of free radical generation. The spin trapping compound may be administered at once, or may be divided into a number of smaller doses to be administered at varying intervals of time. Other methods of systemic administration can also be used, including inhalation or insufflation, subcutaneous, intravenous, and intraperitoneal administration. The spin trapping compound can also be

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administered topically, in an ointment, creme, or transdermal patch.

The spin trapping composition can be provided in the form of a pharmaceutically acceptable salt. As used herein, the term pharmaceutically acceptable salts or complexes refers to salts or complexes of that retain the desired biological activity of the parent compound and exhibit minimal, if any, undesired toxicological effects. Nonlimiting examples of such salts are (a) acid addition salts formed with inorganic acids (for example, hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, nitric acid, and the like), and salts formed with organic acids such as acetic acid, oxalic acid, tartaric acid, succinic acid, malic acid, ascorbic acid, benzoic acid, tannic acid, pamoic acid, alginic acid, polyglutamic acid, naphthalenesulfonic acids, naphthalenedisulfonic acids, and polygalacturonic acid; (b) base addition salts formed with polyvalent metal cations such as zinc, calcium, bismuth, barium, magnesium, aluminum, copper, cobalt, nickel, cadmium, sodium, potassium, and the like, or with an organic cation formed from N,N-dibenzylethylene-diamine, ammonium, or ethylenediamine; or combinations of (a) and (b); e.g., a zinc tannate salt or the like.

A preferred mode of administration of the active compound is in a form for oral delivery. Oral compositions will generally include an inert diluent or an edible carrier. Preferred pharmaceutical carriers for intravenous administration are saline or phosphate buffered saline at physiological pH. Since some compounds are pH sensitive, stability of the compound in the carrier should be determined and the pH of the carrier adjusted appropriately, or the compound administered in combination with food, a buffering agent, or in an enteric coating. For oral delivery, the spin trapping compound may be enclosed in capsules, compressed into tablets, microencapsulated, entrapped in

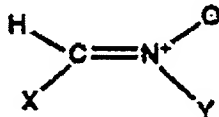
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liposomes, in solution or suspension, alone or in combination with a substrate immobilizing material such as starch or poorly absorbable salts such as immodium. Pharmaceutically compatible binding agents can be included as part of the composition. The tablets or capsules may contain, for example, any of the following ingredients, or compounds of a similar nature: a binder such as microcrystalline cellulose, gum tragacanth or gelatin; an excipient such as starch or lactose, a disintegrating agent such as alginic acid, Primogel®, or corn starch; a lubricant such as magnesium stearate or Sterotes; a glidant such as colloidal silicon dioxide; a sweetening agent such as sucrose or saccharin; or a flavoring agent such as peppermint, methyl salicylate, or orange flavoring. When the dosage unit form is a capsule, it can contain, in addition to material of the above type, a liquid carrier. In addition, dosage unit forms can contain various other materials which modify the physical form of the dosage unit, for example, coatings of sugar, shellac, or other enteric agents.

Modifications and variations of the spin trapping compositions for the treatment of a variety of disorders associated with oxidation of proteins and/or lipids will be obvious to those skilled in the art from the foregoing detailed description. Such modifications and variations are intended to come within the scope of the appended claims.

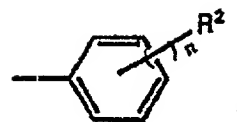
We claim:

1. A pharmaceutical composition comprising a non-toxic spin trapping compound of the formula:



wherein:

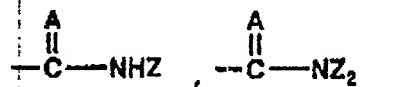
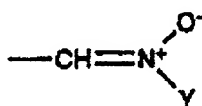
X is phenyl, imidazolyl, phenothiazinyl or



n=1-5, preferably 1-3;

R<sup>2</sup> = independently (can vary within the molecule) halogen, alkyl, oxyalkyl, alkenyl, oxyalkenyl, OH,

NH<sub>2</sub>, NHZ, NZ<sub>2</sub>, NO,



-SO<sub>3</sub>H, -OSO<sub>3</sub>H, SH, -S(alkyl), -S(alkenyl), and haloalkyl, specifically including -CF<sub>3</sub>;

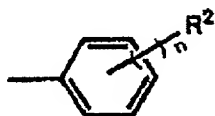
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A = O or S; and

Z is a C<sub>1</sub> to C<sub>6</sub> straight, branched, alkyl or cyclic group;

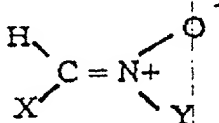
and

Y is a tert-butyl group that can be hydroxylated or acetylated at one or more positions; phenyl or



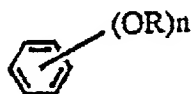
excluding compounds of the formulae:

a)

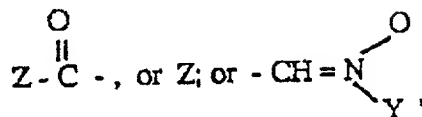


wherein:

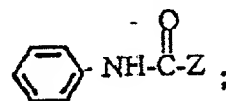
X is phenyl or



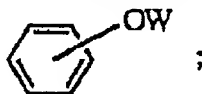
, wherein R is H.



and n is a whole integer from 1 to 5; or



Y is a tert-butyl group that can be hydroxylated or acetylated on one or more positions; phenyl; or

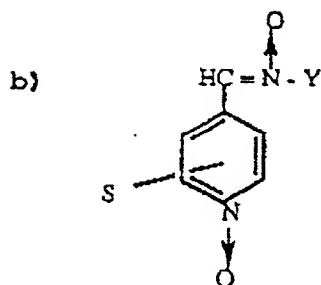


wherein W is  $\text{C}(=\text{O})-\text{CH}_3$ ,  $\text{NH}-\text{C}(=\text{O})-\text{Z}$ ,

$\text{C}(=\text{O})-\text{CH}_3$ ,  $\text{C}(=\text{O})-\text{OZ}$ , or Z; and

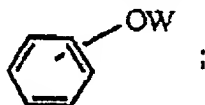
Z is a  $\text{C}_1$  to  $\text{C}_5$  straight or branched alkyl group;

and



wherein

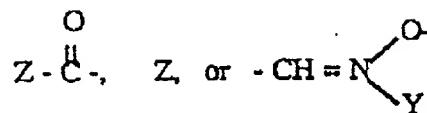
Y is a tert-butyl group that can be hydroxylated or acetylated on one or more positions; phenyl; or



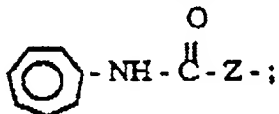
wherein W is  $-\text{C}(=\text{O})-\text{CH}_3$ ,  $\text{NH}-\text{C}(=\text{O})-\text{Z}$ ,

$-\text{C}(=\text{O})-\text{CH}_3$ ,  $-\text{C}(=\text{O})-\text{OZ}$ , or Z; and

$S = H, (OR)_n$ , wherein R is H,



n is a whole number from 1 to 4, or



Z is a  $C_1$  to  $C_8$  straight or branched alkyl group;

in a pharmaceutically acceptable carrier for administration to a patient.

2. The composition of claim 1 wherein the spin trapping compound is covalently linked to a second biologically active molecule.

3. The composition of claim 2 wherein the second biologically active molecule is selected from the group consisting of neuroactive compounds, hormones, enzymes, antibodies, and carbohydrate molecules specifically bound by cell surface receptors.

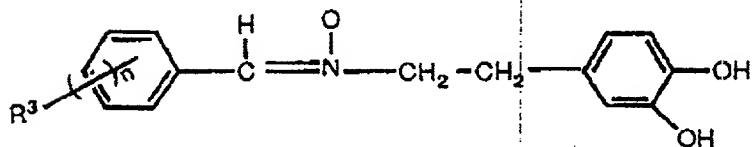
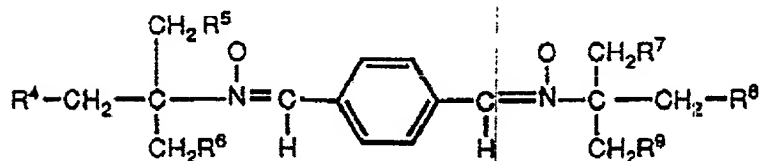
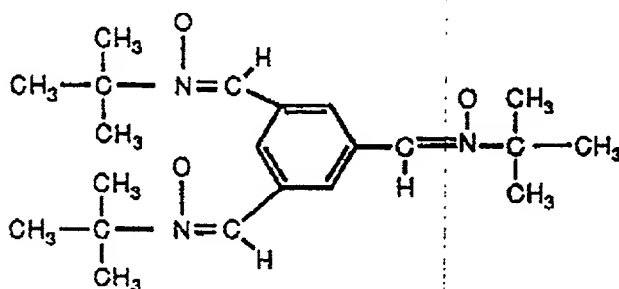
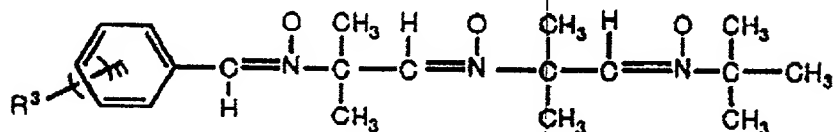
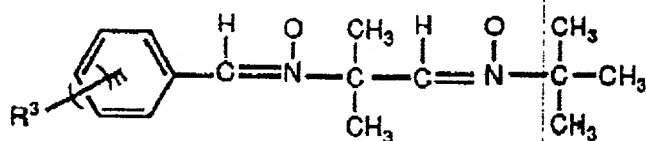
4. The composition of claim 1 wherein multiple units of the spin trapping compound are formed into one molecule for administration to a patient.

5. The composition of claim 1 wherein the pharmaceutical carrier is selected from the group consisting of carriers for intravenous administration, oral administration, administration via the respiratory tract, subcutaneous administration, intramuscular administration, rectal administration, and topical administration.

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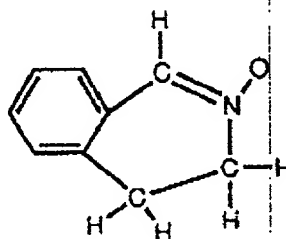
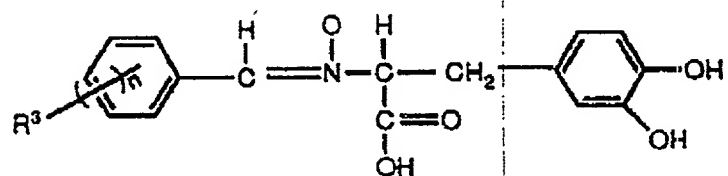
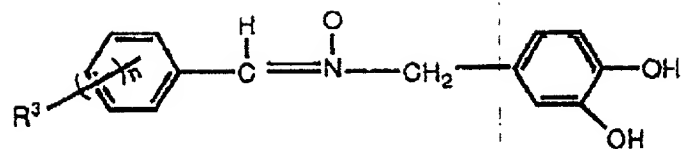
6. The composition of claim 1, wherein the spin trap is selected from the group consisting of:



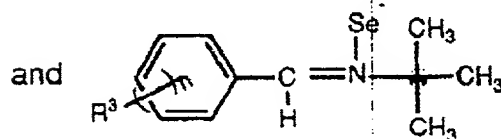
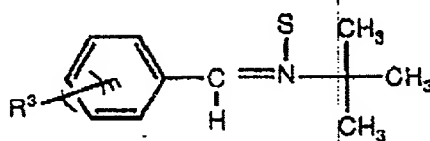
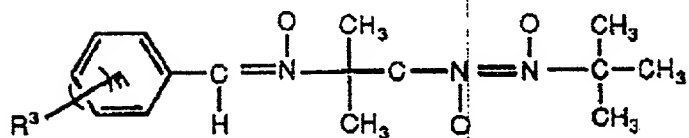
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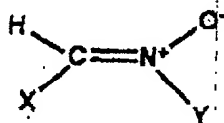


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wherein  $R^3$  = independently  $R^2$  (that can vary within the molecule) or H,  
and  $R^4$  to  $R^9$  are independently  $R^2$ , H or

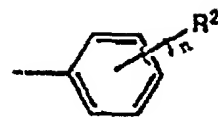


7. Use of a pharmaceutical composition comprising a non-toxic spin trapping compound of the formula:



wherein:

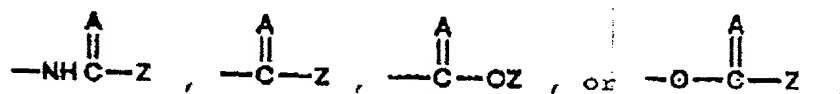
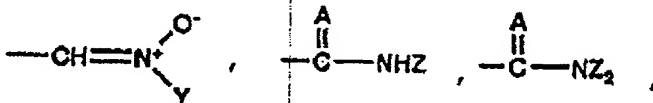
X is phenyl, imidazolyl, phenothiazinyl or



$n=1-5$ , preferably 1-3;

$R^2$  = independently (can vary within the molecule) halogen, alkyl, oxyalkyl, alkenyl, oxyalkenyl, OH,

$NH_2$ ,  $NHZ$ ,  $NZ_2$ ,  $NO$ ,



$-SO_3H$ ,  $-OSO_3H$ ,  $SH$ ,  $-S(alkyl)$ ,  $-S(alkenyl)$ , and haloalkyl, specifically including  $-CF_3$ ;

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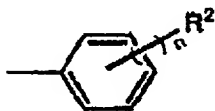
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A = O or S; and

Z is a C<sub>1</sub> to C<sub>6</sub> straight, branched, alkyl or cyclic group;

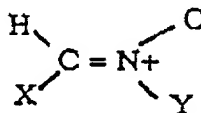
and

Y is a tert-butyl group that can be hydroxylated or acetylated at one or more positions; phenyl or

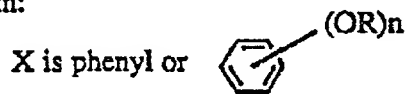


excluding compounds of the formulae:

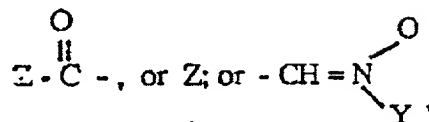
a)



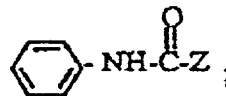
wherein:



, wherein R is H,

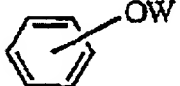


and n is a whole integer from 1 to 5; or



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Y is a tert-butyl group that can be hydroxylated or acetylated on one or more positions; phenyl; or  ;

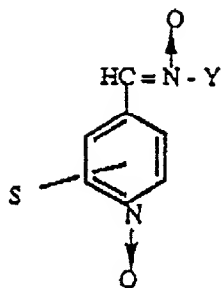
wherein W is  $\text{C}(=\text{O})-\text{CH}_3$  ,  $\text{NH}-\text{C}(=\text{O})-\text{Z}$  ,

$\text{C}(=\text{O})-\text{CH}_3$  ,  $\text{C}(=\text{O})-\text{OZ}$  , or Z; and

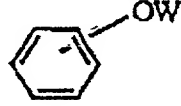
Z is a  $\text{C}_1$  to  $\text{C}_5$  straight or branched alkyl group;

and

b)



wherein

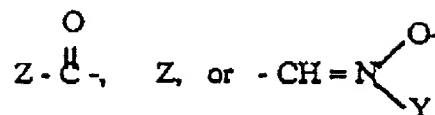
Y is a tert-butyl group that can be hydroxylated or acetylated on one or more positions; phenyl; or  ;

wherein W is  $-\text{C}(=\text{O})-\text{CH}_3$  ,  $\text{NH}-\text{C}(=\text{O})-\text{Z}-$  ,

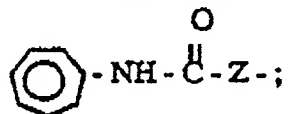
$-\text{C}(=\text{O})-\text{CH}_3$  ,  $-\text{C}(=\text{O})-\text{OZ}$  , or Z; and

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$S = H, (OR)_n$ , wherein R is H,



n is a whole number from 1 to 4, or



Z is a  $C_1$  to  $C_8$  straight or branched alkyl group;

in a pharmaceutically acceptable carrier in the manufacture of a medicament for the treatment of a disorder associated with oxidation of a protein or a lipid wherein the disorder is a disorder of the central or peripheral nervous system or a disorder of a peripheral organ.

8. The use according to claim 7 wherein the disorders of the central nervous system are selected from the group consisting of stroke, aging, Parkinsonism, concussion, aneurysm, ventricular hemorrhage and associated vasospasm, migraine and other vascular headaches, spinal cord trauma, and neuroanesthesia adjunct.

9. The use according to claim 7 wherein the disorders of the peripheral nervous system are selected from the group consisting of diabetic peripheral neuropathy and traumatic nerve damage.

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10. The use according to claim 7 wherein the disorders of the peripheral organs are selected from the group consisting of atherosclerosis, chronic obstructive pulmonary disease (COPD), pancreatitis, pulmonary fibrosis due to chemotherapeutic agents, angioplasty, trauma, burns, ischemic bowel disease, wounds, ulcers and bed sores, lupus, ulcerative colitis, organ transplantation, renal hypertension, overexertion of skeletal muscle, and epistaxis (pulmonary bleeding).

11. The use according to claim 7 wherein the disorders are a result of exposure to radiation.

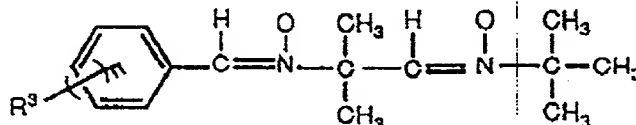
12. The use according to claim 7 wherein the disorders are a result of exposure to cytotoxic compounds.

13. The use according to claim 7 wherein the disorder is oxidation of low density lipoprotein.

14. The use according to claim 7 wherein the composition is administered in a pharmaceutical carrier for topical application.

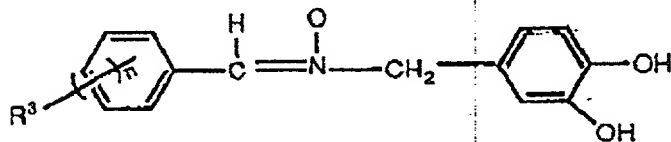
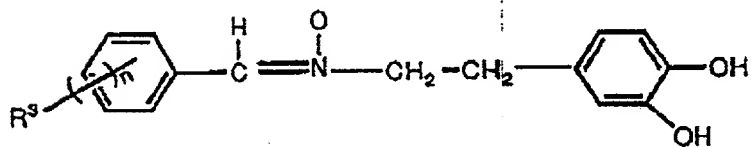
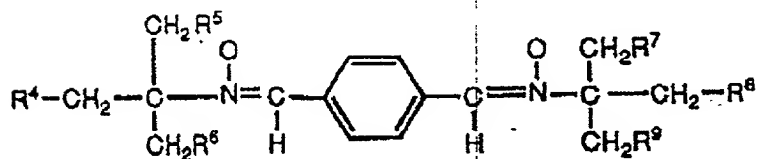
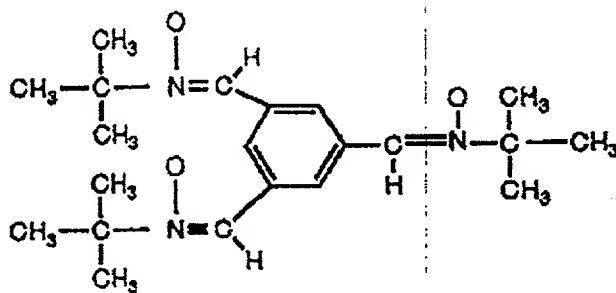
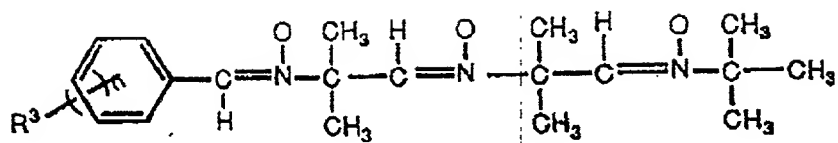
15. The use according to claim 7 wherein the composition is administered systemically.

16. The use according to claim 7, wherein the spin trap is selected from the group consisting of:



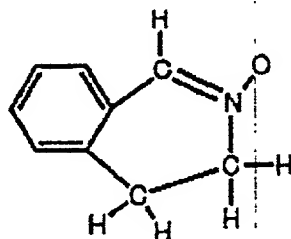
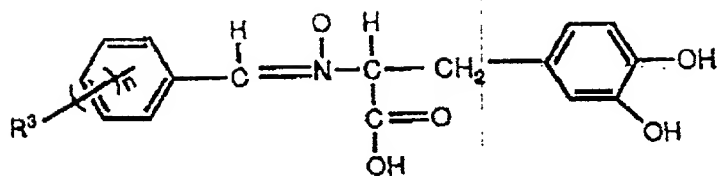
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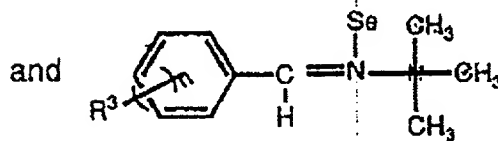
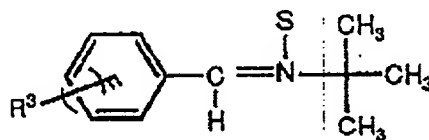
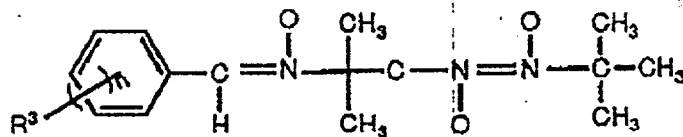


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wherein  $R^3$  = independently  $R^2$  (that can vary

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within the molecule) or H;

and  $R^4$  to  $R^9$  are independently  $R^2$ , H or



SPIN TRAPPING PHARMACEUTICAL COMPOSITIONS  
AND METHODS FOR USE THEREOF

Abstract of the Invention

Spin trapping compositions in general have now been discovered to be effective in treating a variety of disorders, including disorders such as those arising from ischemia, infection, inflammation, exposure to radiation or cytotoxic compounds, not just of the central and peripheral nervous systems but of peripheral organ disease having a wide variety of etiologies. In the preferred embodiment, the compositions for treating tissue damage from ischemia contain PBN, or active derivatives thereof, in a suitable pharmaceutical carrier for intravenous, oral, topical, or nasal/pulmonary administration. Other preferred spin-trapping agents include 5,5-dimethyl pyrroline N-oxide (DMPO),  $\alpha$ -(4-pyridyl-1-oxide)-N-tert-butyl nitron (POBN), and (TEMPO) and spin-trapping derivatives thereof. Examples of derivatives of PBN include halogenated derivatives, bifunctional derivatives, conjugates with drugs or targeting molecules, dimers and cyclodextran polymers of PBN. Many different disorders can be treated using these compounds, including diseases or disorders of the central and peripheral nervous systems, and disorders arising from ischemia, infection, inflammation, oxidation from exposure to radiation or cytotoxic compounds, as well as due to naturally occurring processes such as aging.

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COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

This declaration is of the following type:

- ☐ original
- ☐ design
- ☐ supplemental
- ☒ national stage of PCT
- ☐ divisional
- ☐ continuation
- ☐ continuation-in-part (CIP)

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed for and for which a patent is sought on the invention entitled:

SPIN-TRAPPING PHARMACEUTICAL COMPOSITIONS AND METHODS FOR USE THEREOF

the specification of which

- ☐ is attached hereto
- ☒ was filed on December 17, 1993, as  
Application Serial No. 08/167,900  
and was amended on \_\_\_\_\_  
(if applicable)
- ☒ was described and claimed in PCT International application  
No. PCT/US92/05194 filed on June 18, 1992  
and as amended under PCT Article 19 on \_\_\_\_\_  
(if any).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any Amendment referred to above.

I acknowledge duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Sec. 1.56.

- ☐ In compliance with this duty there is attached an information disclosure statement. 37 CFR 1.97.

08925040-10349

I hereby claim foreign priority benefits under Title 35, United States Code, Sec. 119, of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent of inventor's certificate having a filing date before that of the application on which priority is claimed:

```
[ ] no such applications have been filed
[ ] such applications have been filed as follows.
```

Prior Foreign Application(s)

<u>(Number)</u>	<u>(Country)</u>	<u>(day/month/year filed)</u>	[ Yes ]	[ No ]
<u>(Number)</u>	<u>(Country)</u>	<u>(day/month/year filed)</u>	[ Yes ]	[ No ]

I hereby claim the benefit under Title 35, United States Code, Sec. 120 of any United States application(s) listed below, and insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Sec. 112, I acknowledge the duty to disclose all information known to be material to patentability as defined in Title 37, Code of Federal Regulations, Sec. 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(patented, pending, abandoned)

**POWER OF ATTORNEY:** As a named inventor, I hereby appoint the following attorney(s) and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

George M. Cooper, Reg. No. 20,201      Eric S. Spector, Reg. No. 22,495  
Felix J. D'Ambrosio, Reg. No. 25,721      Douglas R. Hanscom, Reg. No. 26,600  
James W. Hellwege, Reg. No. 28,808      William A. Blake, Reg. No. 30,548  
Scott W. Brickner, Reg. No. 34,553      Colin D. Barnitz, Reg. No. 35,061  
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Direct telephone calls  
TO: James W. Hellwege  
(703) 415-1500



COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

This declaration is of the following type:

- ☐ original
- ☐ design
- ☐ supplemental
- ☒ national stage of PCT
- ☐ divisional
- ☐ continuation
- ☐ continuation-in-part (CIP)

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed for and for which a patent is sought on the invention entitled:

SPIN-TRAPPING PHARMACEUTICAL COMPOSITIONS AND METHODS FOR USE THEREOF

the specification of which

- ☐ is attached hereto
- ☒ was filed on December 17, 1993, as  
Application Serial No. 08/167,900  
and was amended on \_\_\_\_\_  
(if applicable)
- ☒ was described and claimed in PCT International application  
No. PCT/US92/05194 filed on June 18, 1992  
and as amended under PCT Article 19 on \_\_\_\_\_  
(if any).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any Amendment referred to above.

I acknowledge duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Sec. 1.56.

- ☐ In compliance with this duty there is attached an information disclosure statement. 37 CFR 1.97.

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"FEET" 07020600

I hereby claim foreign priority benefits under Title 35, United States Code, Sec. 119, of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent of inventor's certificate having a filing date before that of the application on which priority is claimed:

[ ] no such applications have been filed  
[ ] such applications have been filed as follows.

Prior Foreign Application(s)

<u>                    </u>	<u>                    </u>	<u>                    </u>	[    ]	[    ]
(Number)	(Country)	(day/month/year filed)	Yes	No
<u>                    </u>	<u>                    </u>	<u>                    </u>	[    ]	[    ]
(Number)	(Country)	(day/month/year filed)	Yes	No

I hereby claim the benefit under Title 35, United States Code, Sec. 120 of any United States application(s) listed below, and insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Sec. 112, I acknowledge the duty to disclose all information known to be material to patentability as defined in Title 37, Code of Federal Regulations, Sec. 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

<u>                    </u>	<u>                    </u>	<u>                    </u>
(Application Serial No.)	(Filing Date)	(patented, pending, abandoned)
<u>                    </u>	<u>                    </u>	<u>                    </u>
(Application Serial No.)	(Filing Date)	(patented, pending, abandoned)

**POWER OF ATTORNEY:** As a named inventor, I hereby appoint the following attorney(s) and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

George M. Cooper, Reg. No. 20,201	Eric S. Spector, Reg. No. 22,495
Felix J. D'Ambrosio, Reg. No. 25,721	Douglas R. Hanscom, Reg. No. 26,600
James W. Hellwege, Reg. No. 28,808	William A. Blake, Reg. No. 30,548
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I hereby declare all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor John M. CARNEY

Inventor's signature \_\_\_\_\_ (Date)

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